Geosat Follow-On Altimeter Height Loop and AGC Loop Step Responses from Ground Testing

G. S. Hayne

NASA Goddard Space Flight Center

Laboratory for Hydrospheric Processes

Observational Science Branch, Code 972

Wallops Island, VA 23337

Last Revised April 16, 1996

This paper reports analysis of special loop transient test data from Geosat Follow-On (GFO) altimeter testing at E-Systems, ECI Division, in St. Petersburg, Florida. The loop transient tests were not part of the normal GFO testing but were performed in response to requests of scientists invited to review the GFO testing data, and the cooperation of Joe Dobrzanski, E-Systems GFR Project Engineer, is gratefully acknowledged. These special test loop transient data show the response of the GFO altimeter to step-changes in the simulated range and simulated backscattered return power. The range is referred to as the height hereafter, and the return power as the AGC (automatic gain control) value. All the height results plotted here will be reduced by 59,947.5 meters relative to the height values on the GFO data tape.

The attached Figure 1 shows a 70-second span of GFO data containing nine step-changes in height, labelled "a" through "i". The altimeter response looks reasonable for these except for transition "e", the largest step of the series. These special transient tests required manually toggling a bank of front panel switches on the Radar Altimeter System Evaluator (RASE). For transition "e" two switches on the RASE needed to be toggled, while all the other transitions required only a single switch to be toggled, and in transition "e" the two separate switch toggling events are clearly visible.

Figure 2 shows the AGC values during the height response test, and there is a transient change in the AGC value at the location of every one of the height steps. The largest AGC transient occurs at step "e", the largest of the ranges steps. Figure 3 shows the significant waveheight values. The SWH effects of the height steps are visible for step "d" and, strikingly, for step "f". Steps "d" and "f" had the same magnitude and direction of range change, so it's puzzling why "f" has so large a SWH transient. Perhaps the loop had not quite recovered from the large transient step "e" when step "f" was made.

We then found the approximate alpha and beta values for the GFO altimeter in the vicinity of the height steps, "a" through "i", except for step "e". At each of these steps an alpha-beta tracker height

tracker simulation was set up with five adjustable parameters: 1) alpha; 2) beta; 3) offset, the index value at which the step change occurs; 4) level 1, the starting height before the index reaches the offset value; and 5) level 2, the height after the offset index. The simulated height step magnitude is (level 2 - level 1). This simulation used the Seasat height loop recursion relations described in Section 4.4 of J. L. MacArthur's report "Seasat - A Radar Altimeter Design Description", (publication SDO-5232, Johns Hopkins University Applied Physics Laboratory, Laurel, MD, November 1978).

The alpha-beta simulation ran at a nominal 20 Hz rate, and successive pairs of simulation output heights were averaged to produce simulated GFO telemetry heights at a nominal 10 Hz rate. These simulated heights were compared with 9-second spans of the actual GFO heights and the five simulation parameters were adjusted to minimize the sum of squares of differences between simulation and test data. The results of this exercise are shown graphically in Figures 4a - 4i; the one exception to the procedure is that the large step case "e" was not fitted for alpha and beta and instead the design alpha and beta values were used. On each of the Figures 4a through 4i the fit coefficients are given; *alpha* and *beta* are the fitted range loop constants, the range step is from *ampl1* to *ampl2*, and the *offset* is the index value where the step occurred. The alpha and beta fit results are summarized in Table 1 which also gives the approximate location and height step size for steps "a" through "f".

Table 1. Alpha and Beta Fit Results for GFO Height Loop Response Test

label	location index	height change, m	fitted alpha	fitted beta
a	50	+1.9	0.279	0.0170
b	130	-1.9	0.218	0.0133
c	220	+3.7	0.260	0.0159
d	320	-3.7	0.190	0.0076
e	470	+5.5	- -	- -
f	511	-3.7	0.199	0.0096
g	550	+3.7	0.236	0.0181
h	609	-1.9	0.199	0.0147
i	639	+1.9	0.247	0.0206

These fit results for alpha and beta are in fairly good agreement with the nominal design values of 1/4 for alpha and 1/64 for beta. It is even reasonable to expect the effective alpha for larger height steps to be smaller than the alpha for small steps, because the larger steps will take the altimeter further away from the region of maximum slope of the tracker discriminator curve; the altimeter is set up so that the value of alpha is 1/4 at the altimeter's nominal track point (which is also at the maximum discriminator slope).

The AGC loop response data were examined in the same way. Table 2, below, summarizes the approximate AGC steps and their locations for the test data which was examined. Figure 5 shows the GFO AGC results from the AGC loop response test, and there are six AGC step-changes identified as "A" through "F". Figure 6 shows the height results during the AGC loop response test, and only step "E" shows an appreciable height transient as a result of the AGC change. Figure 7 shows the SWH results, and again only step "E" has any appreciable SWH transient. The analysis of the AGC response used the alpha-beta fitting procedure already employed in the height response, except that for AGC the beta was held to 0. Figures 8a through 8f show the AGC loop response fit results, and the fitted alpha values are summarized in Table 2.

Table 2. GFO AGC Loop Response Test Summary

label	location index	AGC change, dB	fitted alpha
A	51	+9.6	0.301
B	172	-9.8	0.360
C	271	+9.7	0.307
D	313	-19.5	0.300
E	422	+19.4	0.244
F	479	-9.6	0.381

Our conclusion from all this is that the GFO altimeter responded in a controlled and understandable manner to the step-changes in simulated height and simulated power. For the height response test, the fitted alpha and beta values are in reasonable agreement with the altimeter's design alpha and beta values of 1/4 and 1/64, respectively, for the height loop. The AGC fitted alpha values are consistent with an AGC loop time constant of about 0.2 seconds.
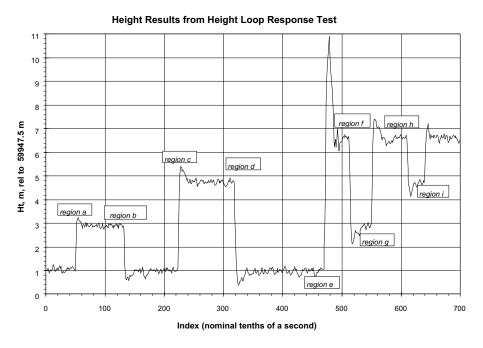
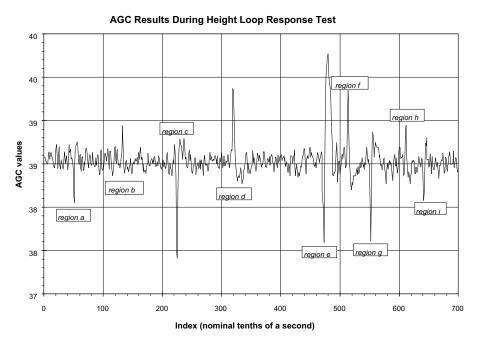**Height Results from Height Loop Response Test**

Figure 1. Height Loop Response Test Data

AGC Results During Height Loop Response Test
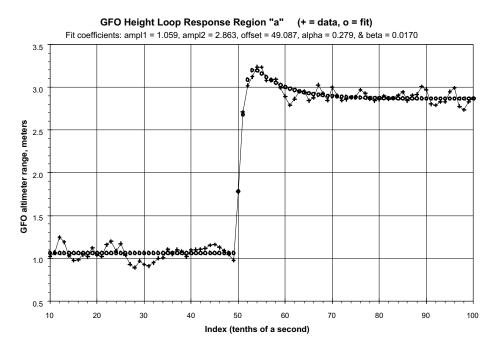

Figure 2. AGC Values in Height Loop Response Test

SWH Results During Height Loop Response Test
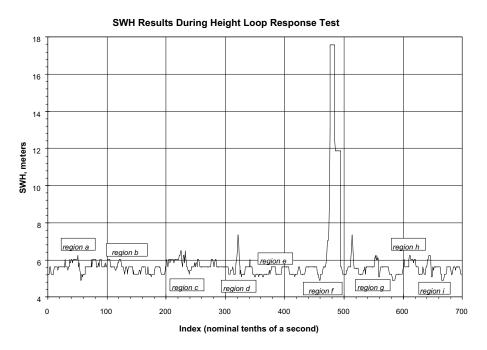
Figure 3. SWH Values During Height Loop Response Test

GFO Height Loop Response Region "a"   (+ = data, o = fit)

Fit coefficients: ampl1 = 1.059, ampl2 = 2.863, offset = 49.087, alpha = 0.279, & beta = 0.0170

Figure 4a. Height Loop Response Data Fit in Region "a"

GFO Height Loop Response Region "b"   (+ = data, o = fit)
Fit coefficients: ampl1 = 2.892, ampl2 = 0.969, offset = 130.833, alpha = 0.218, & beta = 0.0133
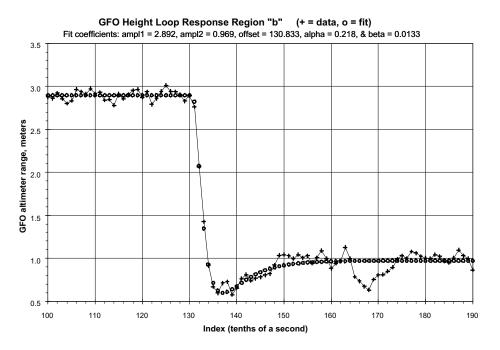
Figure 4b. Height Loop Response Data Fit in Region "b"

GFO Height Loop Response Region "c"   (+ = data, o = fit)
Fit coefficients: ampl1 = 1.012, ampl2 = 4.732, offset = 222.893, alpha = 0.260, & beta = 0.0159
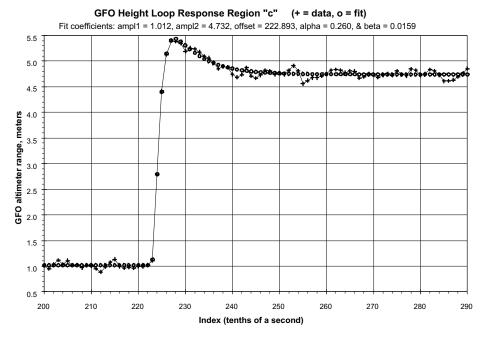
Figure 4c. Height Loop Response Data Fit in Region "c"

GFO Height Loop Response Region "d"   (+ = data, o = fit)

Fit coefficients: ampl1 = 4.735, ampl2 = 1.009, offset = 318.022, alpha = 0.190, & beta = 0.0076
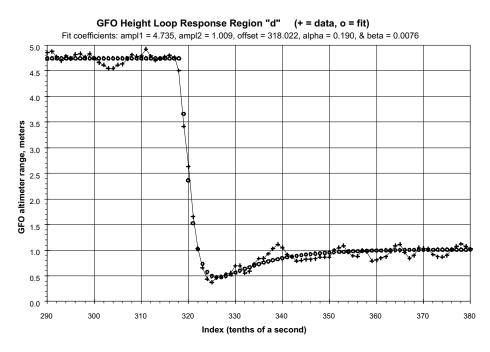
Figure 4d. Height Loop Response Data Fit in Region "d"

GFO Height Loop Response Region "e"   (+ = data, o = fit)

Fit coefficients: ampl1 = 1.100, ampl2 = 6.600, offset = 470.000, alpha = 0.250, & beta = 0.0156
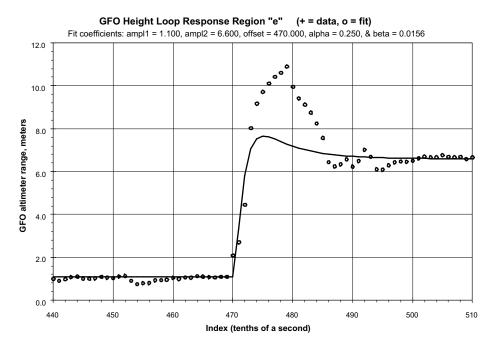
Figure 4e. Height Loop Response Data Fit in Region "e"

(note that no fit is valid because there were two non-simultaneous switch closures for this particular

transition)

GFO Height Loop Response Region "f"   (+ = data, o = fit)

Fit coefficients: ampl1 = 6.635, ampl2 = 2.926, offset = 511.426, alpha = 0.199, & beta = 0.0096
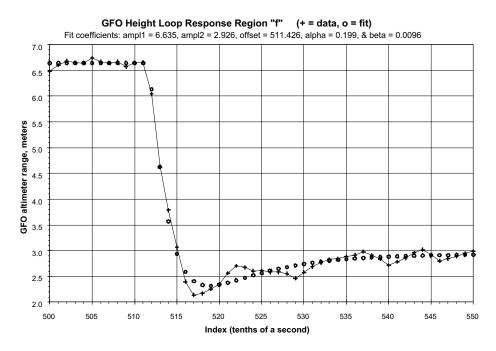
Figure 4f. Height Loop Response Data Fit in Region "f"

GFO Height Loop Response Region "g"   (+ = data, o = fit)

Fit coefficients: ampl1 = 2.873, ampl2 = 6.576, offset = 549.863, alpha = 0.236, & beta = 0.0181
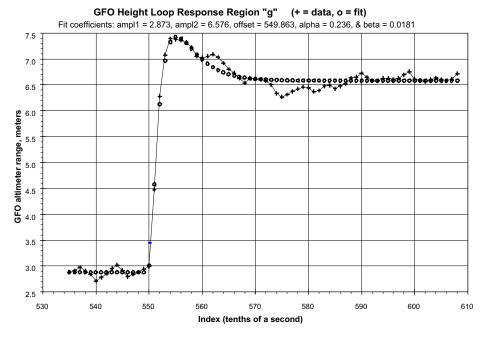
Figure 4g. Height Loop Response Data Fit in Region "g"
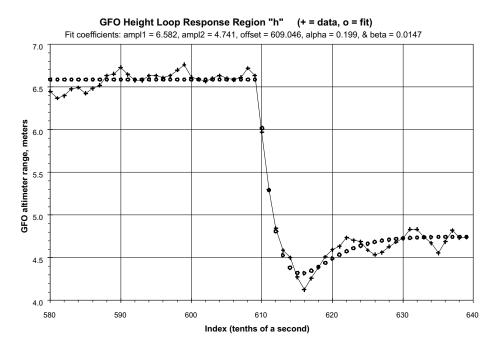
Figure 4h. Height Loop Response Data Fit in Region "h"
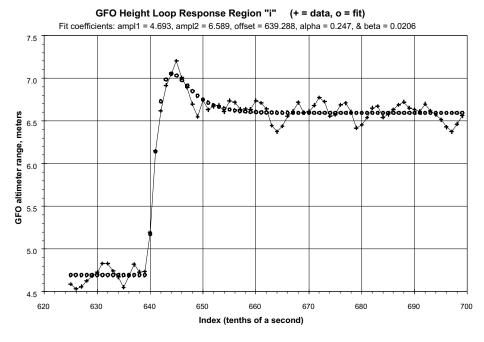
Figure 4i. Height Loop Response Data Fit in Region "i"
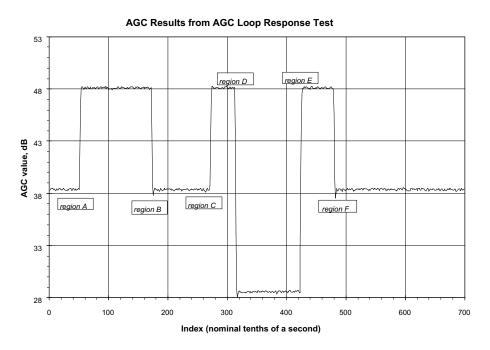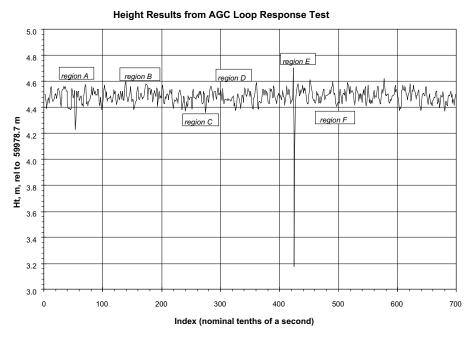
Figure 5. AGC Loop Response Test Data
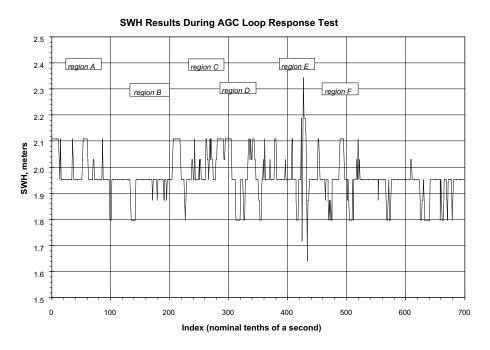

Figure 6. Height Values in AGC Loop Response Test
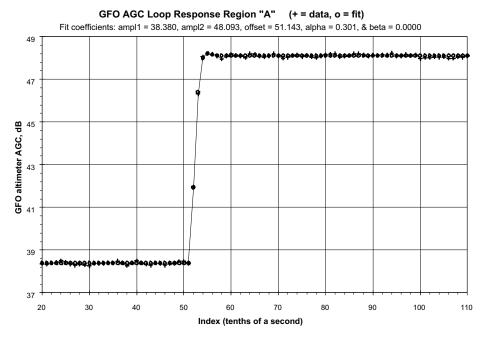
SWH Results During AGC Loop Response Test

Figure 7. SWH Values in AGC Loop Response Test

GFO AGC Loop Response Region "A"   (+ = data, o = fit)

Fit coefficients: ampl1 = 38.380, ampl2 = 48.093, offset = 51.143, alpha = 0.301, & beta = 0.0000

Figure 8a. AGC Loop Response Data Fit in Region "A"

GFO AGC Loop Response Region "B"   (+ = data, o = fit)

Fit coefficients: ampl1 = 48.118, ampl2 = 38.371, offset = 172.127, alpha = 0.360, & beta = 0.0000
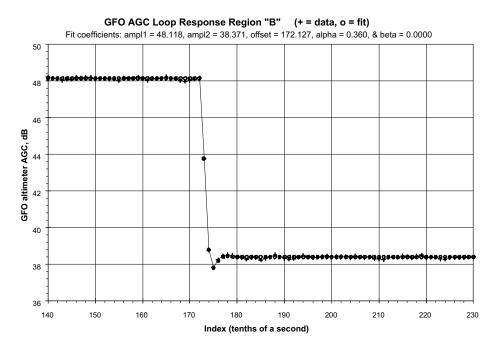
Figure 8b. AGC Loop Response Data Fit in Region "B"

GFO AGC Loop Response Region "E"   (+ = data, o = fit)

Fit coefficients: ampl1 = 38.361, ampl2 = 48.102, offset = 270.903, alpha = 0.307, & beta = 0.0000
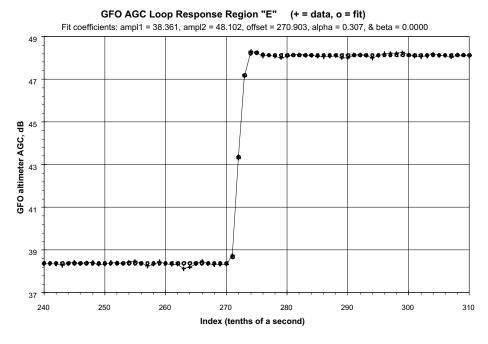
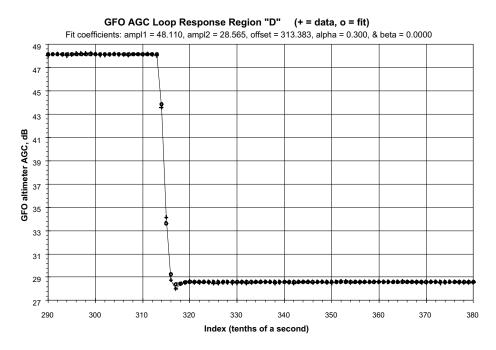**Figure 8c. AGC Loop Response Data Fit in Region "C"**

Figure 8d. AGC Loop Response Data Fit in Region "D"
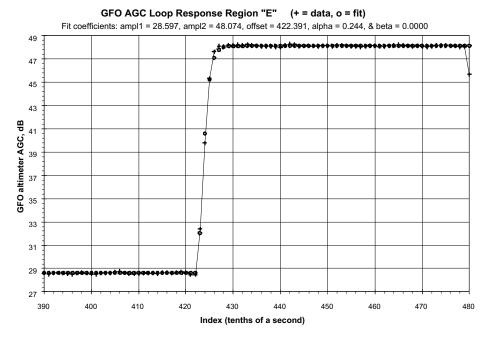

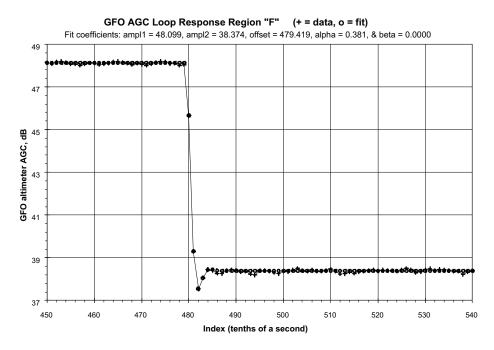**Figure 8e. AGC Loop Response Data Fit in Region "E"**

Figure 8f. AGC Loop Response Data Fit in Region "F"